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Mental Model Updating and Team Adaptation

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Abstract

In this article, we build on theories of team adaptation by exploring the role of team members' cognitive knowledge structures in team adaptation to a changing task context. We introduce the notion of mental model updating as the extent to which team members update their mental models in reaction to a change in the task situation. In a laboratory study we investigate the relations between initial mental model similarity and accuracy, team mental model updating, the development of novel interaction patterns, and postchange team performance. The results indicate that mental model updating is positively related to postchange team performance. Also, team adaptation patterns accounted for the effect of mental model updating on postchange team performance. We did not find evidence for a positive relation between initial mental model similarity and accuracy and mental model updating.

Keywords

mental models, team adaptation, interaction patterns

Organizations often deploy teams to cope with the dynamism, complexity, and uncertainty of their environments (Burke, Stagl, Salas, Pierce, & Kendall, 2006). As a result, teams are frequently confronted with changes in their task

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situation (Arrow, McGrath, & Berdahl, 2000; McGrath & Tschan, 2004) and it is crucial that they are able to adapt their processes rapidly to novel situations (Ilgen, 1999). Although teams may spend large amounts of their time functioning under stable conditions, when faced with unexpected challenges consequential differences in effectiveness among teams often become most evident (LePine, 2003, 2005). Moreover, a team's ability to adapt to novel and challenging circumstances is often crucial for diverting failures and disasters (Stachowski, Kaplan, & Waller, 2009); therefore, much leverage can be gained by identifying elements that contribute to the teams' ability to think on their feet and rapidly adapt.

Previous research suggests that as team members accumulate experience in performing a team task, they rapidly develop stable interaction patterns that constitute a major source of the reliability and speed of team performance (Cohen & Bacdayan, 1994; Gersick & Hackman, 1990; Zijlstra, Waller, & Phillips, 2012). However, the applicability of these interaction patterns is strongly dependent on the context in which they have been developed. When the team is faced with a changing task situation, persevering with previously established routines and interaction patterns can become detrimental for team performance (Cohen & Bacdayan, 1994; Gersick, 1988; Gersick & Hackman, 1990; Stachowski et al., 2009). In particular, if changes occur in the underlying task structure (i.e., in the relationships among task variables and in the relative effectiveness of specific actions), teams must reevaluate the applicability of their existing practices and develop new practices for confronting their novel task situation (LePine, 2003; Marks, Zaccaro, & Mathieu, 2000). To effectively deal with novel situations, teams must adapt to changes in the task situation and respond with appropriate actions (LePine, 2003). Consequently, team adaptation has been defined by Burke and colleagues (2006) as "a change in team performance, in response to a salient cue or cue stream, that leads to a functional outcome for the entire team" (p. 1190).

Authors have emphasized the importance of the structured knowledge team members have regarding their task or team in the team adaptation process (Burke et al., 2006; Marks et al., 2000). In particular, team mental models—team members' mental representations of knowledge, relationships, or systems—are considered pivotal for successful team adaptation (Cannon-Bowers, Salas, & Converse, 1993). However, previous works, while explicating the role of mental models in team adaptation often take a static perspective on team cognition, focusing on characteristics such as similarity, accuracy, or quality (DeChurch & Mesmer-Magnus, 2010). Yet research from the field of managerial and organizational cognition suggests that under dynamic task circumstances, it may not be the momentary stable characteristics of mental models that impacts performance, but the ability to update mental models in light of changing task situations (e.g., Barr, Stimpert, & Huff, 1992; Bartunek, 1984; Weick, 1979).

We argue that team members should update their mental models in response to changes in their task situation; however, the extent to which they will have to adjust depends on the magnitude of the change (e.g., Moorman & Miner, 1997). Scholars have distinguished between two qualitatively different types of change: evolutionary and radical change (e.g., Gersick, 1991; Miller & Friesen, 1984). Whereas in evolutionary change the main elements from the previous period may still hold, radical change refers to a complete restructuring of the forces constructing the relevant environment, or as Gersick cogently illustrated, "the difference between changing the game of basketball by moving the hoops higher and changing it by taking the hoops away" (1991, p. 19). In the present study we focus on changes that lie somewhere between these two extremes that are large enough to require teams to abandon some previously acquired routines and practices, but not so large that all previous knowledge becomes irrelevant; thus, the magnitude of change should be considered as a boundary condition of the study.

Whereas some scholars have hinted at the effect of dynamic aspects of mental models on team adaptive performance (e.g., Marks et al., 2000), empirical research on these dynamic effects are lacking. Therefore in the present article, we test whether team member mental model updating—changing mental models in line with changes in the task situation—is positively related to team performance in a situation requiring adaptation. In addition, we test whether initial mental model similarity and accuracy are antecedents of mental model updating. Finally, we investigate whether the development of novel interaction patterns after a change mediates the relationship between mental model updating and postchange team performance. We test our hypotheses in a study of 46 three-person teams performing tasks during a firefighting simulation requiring an unexpected adaptation in task strategies.

Theory and Hypotheses

Mental Model Updating and Postchange Team Performance

Mental models may be the most widely researched aspect of team cognition. Mental models are organized knowledge structures consisting of the content and the structure of the concepts in the mind of individuals that represent a specific task or knowledge domain (Mohammed, Ferzandi, & Hamilton, 2010). Scholars have argued that team members may hold mental models for various aspects of their task, including the equipment, the task itself, the team interaction, and the other team members and that different types of mental models can be more important in different situations (e.g., Cannon-Bowers et al., 1993; Cooke et al., 2003). In the present study we are interested in team adaptation to a change in the external task context, so we focus on team members' mental representations regarding the relationships among the most important components of their task situation.

Team researchers have operationalized the mental model concept along two main characteristics: similarity and accuracy (Mohammed et al., 2010). Mental model similarity refers to the distribution and overlap of the mental models of the members of a team (Cannon-Bowers et al., 1993). In both field and simulated settings, research on shared mental models indicates that similarity of team members' mental models facilitates team processes and team performance (e.g., DeChurch & Mesmer-Magnus, 2010). Authors have argued that shared mental models are particularly important for team adaptive performance, as similarity in knowledge structures fosters the implicit coordination required for rapid coordination in novel situations (Cannon-Bowers et al., 1993; Rico, Sánchez-Manzanares, Gil, & Gibson, 2008). Moreover, a number of studies indicate that apart from mental model similarity, mental model accuracy—the extent to which team members' mental models depict the actual or optimal structure of the team—is also important for team performance (Edwards, Day, Arthur, & Bell, 2006; Lim & Klein, 2006; Marks et al., 2000).

However, the concepts of mental model similarity and accuracy provide a rather static depiction of the team knowledge structures at a single point in time, whereas in a dynamic situation, it may actually be team members' ability to update their representation of the task situation that impacts whether team members are able to adjust to a novel task situation (Burke et al., 2006; Marks et al., 2000). Empirical studies on team mental models to date have not explicitly examined how team mental models may change over time in reaction to changes in the task structure. When mental models were assessed at several points in time, researchers were mainly interested in the development and stability of team mental model similarity and accuracy over time and, consequently, changes in the underlying structure of those mental models were not examined (e.g., Cooke et al., 2003; Edwards et al., 2006; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005).

In a stable task environment, development of team members' mental models may follow a linear development toward increasing convergence with one (or more) optimal model(s). In an unstable environment, however, the trajectory of mental model development is inherently nonlinear, as a mental model that is effective at one point in time may quickly become suboptimal at a later point in time. For example, many companies in the airline and trucking industries suffered as their managers held on to operational models that had previously been optimal but quickly became outdated after the deregulation of these industries (Audia, Locke, & Smith, 2000). Therefore, a study that aims to assess the quality of team mental models over time in an unstable environment should incorporate this nonlinearity and assess if changes in the task structure are incorporated in the mental models to reflect the task situation. In a simulation study, Marks and colleagues (2000) assessed team mental models under different conditions and found that high performing teams appeared to flexibly adapt their mental models in novel contexts. However, they did not formally test this proposition and they did not include mental model flexibility or updating as variables in their research model.

When a team functions in a dynamic task situation characterized by changes in the relative importance of different task elements, the mental models team members have of the task should also be fluid and changeable. Studies of mental model accuracy clearly indicate that it is vital for team performance that team members' mental models appropriately represent the underlying structure of the task situation (Edwards et al., 2006; Lim & Klein, 2006). This implies that when a team's task situation changes, alterations in the underlying structure of that situation should be matched with corresponding modifications in team members' task mental models, or teams will run the risk of acting on an impoverished or outdated view of reality (Weick, 1979). It is not similarity or accuracy of mental models per se, but rather the team members' ability to update their mental models in the light of changes in the task situation that is pivotal to team adaptation. Therefore we predict that, when faced with a sudden and unexpected change in task structure, the team members' ability to revise and update their task mental models to more closely align with the new task situation will be positively related to the team's ability to perform well under nonroutine circumstances. Note that this implies that not all change in mental models is necessarily beneficial to performance. We expect that task mental model updating, which brings them in line with the changes in the task structure, will be particularly beneficial for postchange team performance. Therefore we hypothesize that

Hypothesis 1: Team members' task mental model updating after a change in the task situation will be positively related to postchange team performance.

Initial Mental Model Similarity and Mental Model Updating

A consistent body of research indicates that similarity in team members' mental models facilitates efficient teamwork and consequently leads to high performance (Cannon-Bowers et al., 1993; Mathieu et al., 2005). However, research on the role of prechange mental model similarity in team adaptation to novel circumstances is equivocal.

Burke and coauthors (2006) emphasized the importance of shared mental models for the formulation and execution of new plans and strategies in novel environments. They stated that "[in] the absence of shared mental models adaptive team performance is not possible, because members do not have compatible views of equipment, tasks, and team member roles and responsibilities, which allow members to adapt proactively" (p. 1194). Similarly, Marks and colleagues (2000) pose that under high environmental dynamism, the positive relationship between mental model similarity and accuracy and team performance will be even more pronounced than under low degrees of environmental dynamism. In a low-fidelity three-person team simulation, they found positive main effects as well as an interaction effect of mental model similarity and accuracy on team adaptive performance. The interaction indicated that team mental model similarity was particularly important for teams with less accurate mental models. Based on this result, Marks et al. suggest that if team members have similar mental models, these do not necessarily have to be initially accurate because having similar mental models may help them to construct accurate mental models as well.

Although existing research seems to imply a positive relationship between mental model similarity and team adaption, several scholars have voiced their concern that too much similarity may, under specific conditions, hinder effective adaptation (e.g., Cannon-Bowers et al., 1993; Klimoski & Mohammed, 1994). Cannon-Bowers and colleagues (1993) wondered if a threshold of similarity in mental models may be surpassed, such that individuals' contributions may become lost and a team's cognitive functioning may become overly rigid. In addition, a number of recent studies have reported negative effects of mental model similarity on team performance. For example, a study by Kellermanns, Floyd, Pearson, and Spencer (2008) indicates that when teams have strong norms for constructive confrontation, mental model similarity may be negatively related to performance. They argue that in contrast to teams with similar mental models, teams with dissimilar mental models have greater diversity of cognitive inputs, which can benefit the team in case they have constructive norms for team interaction.

Although the above mentioned studies do not relate specifically to team performance in situations requiring adaptation, an investigation of the role of shared mental models in the cognitive processes of team adaptation provides additional information on the possible negative effects of mental model similarity on team adaptation. First, given that mental models guide perception and interpretation processes (Neisser, 1976; Starbuck & Milliken, 1988), similarity in mental models may be negatively related to the variety of cues that is considered within a team. Similarity may thereby reduce the chance that the team will notice the relatively atypical cues that may signal a need for change. Second, the development of novel plans and strategies has often been associated more strongly with cognitive diversity than with cognitive similarity (Jehn, Northcraft, & Neale, 1999). The information processing perspective on diversity (van Knippenberg & Schippers, 2007) suggests that because teams with diverse knowledge structures have at their disposal a wider variety of opinions and perspectives, they are more likely to engage in deep information processing to integrate these various viewpoints. Deep information processing, in turn, is related to a team's ability to reconsider assumptions and produce more creative and high quality solutions (de Dreu & West, 2001; Nemeth, 1986).

In sum, there seem to be two divergent paths from mental model similarity to team adaptation. On one hand, mental model similarity facilitates crucial team processes such as communication and backup behavior, which are essential for coordinating actions in complex environments (Burke et al., 2006; Rico et al., 2008). On the other hand, similarity may be negatively related to the depth of a team's information processing when faced with changes in its task situation (Hinsz et al., 1997), and this may negatively impact team adaptation (Uitdewilligen, Waller, & Zijlstra, 2010). In the present study, we focus on team members' mental models of their external task environment, which are central to team information processing regarding task structure adaptation. Moreover, team members' mental representations of their task situation are only indirectly related to the interactions among team members. Hence, we expect the negative path to be more prominent regarding this type of mental model, and propose that

> *Hypothesis 2*: Team members' initial task mental model similarity will be negatively related to mental model updating after a change in the task situation.

Initial Team Mental Model Accuracy and Team Mental Model Updating

An analysis of the extant literature provides us with two opposing perspectives regarding the relationship between initial mental model accuracy and mental model updating. First, given that previous research has consistently linked mental model accuracy to successful performance (e.g., Edwards et al., 2006), initial mental model accuracy may lead to a *paradox of success*. Research on the paradox of success implies that initial success may hinder adaptation to changing circumstances (Audia et al., 2000; Miller, 1993). A number of studies, mainly on the organizational level, suggest that past success may lead to dysfunctional strategic persistence after a radical environmental change (Audia et al., 2000; Lant, Milliken, & Batra, 1992; Miller & Chen, 1994). For instance, Audia and colleagues (2000) found in a simulation study that individuals who initially experienced high levels of success were more satisfied, sought less information, set higher goals, and became more confident in the effectiveness of their current strategies, which subsequently led to more strategic persistence. Thus high levels of past success may decrease the motivation to engage in additional cognitive processing and lead to persistence and a lack of change in mental models despite changes in the environment (Fiske & Taylor, 1984; Kiesler & Sproull, 1982). Hence it seems reasonable to extrapolate and infer that teams with mental models that in the past have consistently led to good performance will be less likely to change these mental models than will teams with mental models that have not previously been associated with good performance.

On the other hand, initially accurate mental models may provide teams with a more advantageous starting point to develop new accurate mental models than teams that did not initially have accurate mental models. Three arguments can be given for this positive relationship between mental model accuracy and mental model updating. First, even though some linkages among concepts may no longer hold in the new situation and some others will have to be developed, it is unlikely that all relationships among all concepts will have to be completely restructured. Hence the net amount of relationships among concepts that has to be changed from an initially accurate mental model to a new accurate mental model is likely to be smaller than from an initially inaccurate mental model to a new accurate mental model. Second, the accuracy of the initial mental model may reflect an underlying ability to construct accurate mental models. For example, Edwards and colleagues (2006) found a positive relationship between team ability and mental model accuracy. This ability may also be beneficial in the adaptation of the initial mental model to the new task situation (LePine, 2005). Third, the positive effect of initial accuracy on performance may generate additional effects that positively affect mental model updating. For example, initially accurate mental models may make task performance more efficient and thereby free up cognitive resources that may be used for consecutive processes of task performance and adaptation (Ericsson & Kintsch, 1995; Rouse & Morris, 1986). Thus efficient teams will have more cognitive resources left for scanning their environments for cues signalling a need for change and for developing appropriate strategies to deal with such change (Thorngate, 1976).

Whether previously accurate mental models will be conducive or detrimental to mental model updating is likely to depend on the degree of change in the task situation the team is facing. As we described under the boundary condition of the present study, although the type of change we focus on in this study is quite drastic, it is not as extreme as the radical environmental changes reported, for example, in the studies of Audia and colleagues (2000). Therefore, we expect the arguments for a positive relationship between team members' initial mental model accuracy and mental model updating to be more in line with the present study. Hence we hypothesize that

> *Hypothesis 3*: Team members' initial mental model accuracy will be positively related to mental model updating after a nonroutine change.

The Mediating Role of Postchange Team Interaction Patterns

Whereas team mental model updating may be crucial to team adaptation, team members' actual task related behaviors or interaction patterns are a more proximal antecedent of adaptive team performance (LePine, 2005). Team interaction patterns are the recurring interlocking patterns of activity, both verbal and nonverbal, that team members perform during a task performance episode (LePine, 2003; Zellmer-Bruhn, Waller, & Ancona, 2004). Team interaction patterns consist of the repeated sequences of behaviors often executed by different team members. When team members' actions co-occur at a higher-than-chance frequency, this indicates a stable underlying pattern of behavior (Stachowski et al., 2009). Interaction patterns closely resemble the notion of habitual routines, which are formally defined by Gersick and Hackman (1990) as "when a group repeatedly exhibits a functionally similar pattern of behavior in a given stimulus situation without explicitly selecting it over alternative ways of behaving" (p. 96). However, whereas team habitual routines are considered to be largely automatic (i.e., they are triggered and executed without conscious deliberation), interaction patterns are defined less stringently and hence may be consciously selected and executed as well as automatic.

Previous research offers competing views regarding the relationship between team interaction patterns and team adaptive performance. On one hand, team interaction patterns are considered to facilitate team adaptive performance because the stability inherent in repetitive patterns increases predictability and thereby facilitates interpersonal coordination of behavior (Kanki, Folk, & Irwin, 1991). Moreover, automaticity of behavior reduces the load on working memory and thereby frees up mental resources, which may be used for other activities, such as scanning the environment and developing alternative action plans (Cohen & Bacdayan, 1994; Thorngate, 1976). On the other hand, researchers have pointed out that habituated interaction patterns may be related to rigidity and demonstrate an inability of teams to discard interaction patterns that have become dysfunctional; instead, teams flexibly develop new ones (Cohen & Bacdayan, 1994; Gersick & Hackman, 1990). When situations are perceived as threatening, people tend to become rigid and fall back on well-learned responses (Staw, Sandelands, & Dutton, 1981). Although well-learned responses may be functional under relatively stable circumstances, they can become detrimental when the task becomes nonroutine and requires divergent interaction patterns than the ones originally developed. For example, Stachowski and colleagues (2009) found that during a crisis situation, higher performing nuclear power plant crews exhibited fewer, shorter, and less complex interaction patterns than less effective crews, which suggest that team effectiveness is driven by teams' ability to shed established patterns of interaction and develop new ones.

Additional evidence for the notion that team adaptive performance depends on a team's ability to rapidly develop novel interaction patterns after a change can be found in recent research on coordination flux (Summers, Humphrey, & Ferris, 2012). Summers et al. (2012) found that the amount of confusion and uncoordinated activity present during the period of flux—that is, the period during which a team abandons its old routines and patterns to create or adopt new ones—is negatively related to the performance of the team. Although Summers and colleagues did not investigate the duration of flux, it seems reasonable to believe that the longer the period of flux, the more prolonged the confusion and the more negative the effect on team performance. This view is further supported by the finding of LePine (2003) that the amount of newly developed interaction patterns in the period immediately following the change was positively related to postchange team performance.

When team members have updated their mental models they are likely to modify their task strategies, which should be represented by the development of novel interaction patterns. Previous research suggests that mental models underlie the task strategies team members apply in confronting their environment (Marks et al. 2000; Mathieu et al., 2005). A change in mental models is thus likely to be associated with a change in the strategy the team applies to a specific task. Some initial evidence for this comes from a study by Randall, Resick, and DeChurch (2011), in which they found that the extent to which team members' mental models reflected the optimal strategy after a task change predicted whether teams adapted their strategies. The implementation of a novel strategy entails the modification of goal-directed actions and interactions among the team members (Hackman, Brousseau, & Weiss, 1976). So, when team members have incorporated the change in the task situation into their mental models, they will develop and implement novel interaction patterns for dealing with the changed task situation (Kozlowski, Gully, Nason, & Smith, 1999). Therefore, we propose that the amount, variety, and complexity of novel team interaction patterns after the structural change will mediate the relationship between mental model updating and postchange team performance.

Hypothesis 4: The amount, variety, and complexity of team interaction patterns after the structural change mediate the relationship between mental model updating and postchange team performance

Method

Sample

Participants in the study were 138 undergraduate students from two universities. The first sample contained 102 participants from a large North American business school (NA) and the second sample contained 36 students from a large Western European business school (WE). Students were randomly assigned to three-person teams resulting in a total of 46 teams. Of the participants in the sample, 61 (NA = 45.1 %, WE = 41.7 %) were female. As for country of origin 50 (NA = 47.1 %, WE = 5.6 %) indicated a North American country, 35 (NA = 32.4 %, WE = 8.3 %) indicated an Asian country, and 45 (NA = 8.8 %, WE = 89.9 %) a European country. Their average age was 20.9 years old (NA = 20.7, WE = 21.4). Although there were differences between the samples in terms of country of origin and there was a small but significant difference in mean age between the samples, independent sample *t* tests indicated that students from the two samples did not differ significantly on the main variables tested in this study. All students participated in team simulation sessions that lasted approximately 100 min for which they received a small amount of course credit. In addition, to motivate goal-directed team functioning, all members of the three highest performing teams received prize certificates worth approximately 10, 25, and 50 USD per team member, respectively.

Task

We used a computer-based real-time command-and-control fire fighting simulation called Networked Fire Chief (NFC) as our research platform. NFC was developed as a psychological research tool to investigate command and control decision making in complex dynamic situations (Omodei, Taranto, & Wearing, 2003). For each team, the simulation runs on three networked computers simultaneously. The teams' task is to minimize the overall damage caused by fire outbreaks occurring at preestablished time points on locations on a map of a village environment. Team members work together from their individual computers and have at their disposal fire trucks and helicopters for extinguishing fires, and bulldozers for clearing grounds (which prevents fires from spreading). Whereas two of the team members are only able to scroll through the map at a detailed level, one of the team members is able to zoom out to an overview map of the complete area. All members have information displayed about the actual and predicted wind strength and direction (as wind influences the spread of the fire). Team members were seated apart so they could not see each other and could communicate with each other only via a computerized chat function.

Task situation change. Consistent with previous studies on team adaptation, we adopted the task-change paradigm to assess postchange team performance (LePine 2003, 2005; Marks et al., 2000). In this paradigm, teams are trained in one context until they possess a basic proficiency in executing the team task. Then some aspect of the task situation changes so that the team must adapt its behaviors to appropriately address the new task context (Lang & Bliese, 2008). We programmed the NFC simulation so that halfway through the time period of the team task, important changes would occur in the strength and direction of the wind and in the size and intensity of fires. These changes in the task situation were not immediately apparent to the team members as fires occurred at irregular intervals and team members needed to deduce the effects of the wind on the spreading of the fires. Due to these changes, tactics and interaction patterns that are optimal in the first half of the simulation become suboptimal in the second half of the simulation. As in the first part of the simulation, speed of locating and responding to fires is crucial for success, an optimal pattern would include the team member with the overview spotting fires and sending vehicles to the fire location, followed by the other members using the helicopter and fire engine to rapidly extinguish the fire. As in the second part of the simulation, containing the fire and preventing it from spreading became more important; teams would fare better if one team member used the bulldozer to prevent the fire from spreading toward the villages after which the other members used the helicopter and fire engine to extinguish any remaining fire.

Procedure

Sessions lasted about 100 min in total and contained an introduction phase, a practice trial phase, and a simulation phase. In the introduction phase, students filled in a general background questionnaire and were instructed on the use of the simulation by means of a standardized presentation. After the presentation followed a 15-min practice trial during which the team members could familiarize themselves with the controls and coordination requirements of the simulation. Following the practice trial, students were given 5 min to communicate via a computerized chat function to develop a strategy; immediately after this communication, participants' mental models were assessed with a written instrument (explained in more detail below).

After completing this instrument, students were notified that the actual simulation would start. The simulation trial duration was 30 min; the nonroutine change in task structure began after 15 min. After 20 min, team members filled in the second mental model instrument. After the simulation, students filled in a final questionnaire, and then they were debriefed and thanked for their participation.

Measures

Team mental models. We used association matrices (Edwards et al., 2006; Mathieu et al., 2005) to assess team members' mental models of the development and spreading of fires. By means of a detailed task analysis of the simulation and the technical documentation, and with the help of a focus group consisting of people who were experts on the simulation (Mathieu et al., 2005), we derived seven concepts that are most critical for understanding the development of the fires: (a) fire intensity, (b) spreading of fire, (c) landscape flammability, (d) direction of wind, (e) speed of wind, (f) burnt area, and (g) difficulty of extinguishing fires.

Team members were asked to fill in matrices in which they indicated how strong they considered each of these concepts to be related to all other concepts. *Mental model similarity* is assessed by the quadratic assignment proportion correlation between the mental models of the different team members. The quadratic assignment proportion is a measure of association among the matrices based on a Pearson's correlation coefficient on the corresponding cells of the data matrices (Mathieu et al., 2005).

To assess initial team *mental model accuracy*, we calculated the average quadratic assignment proportion correlation of each team member's mental model with a referent mental model. To derive a referent mental model, we asked six subject matter experts to independently complete the mental model measure. As subject matter experts we used six additional bachelor students whom we extensively trained to perform the team task under normal task circumstances. The use of trained subject matter experts for deriving expert mental models is common in the literature and has been proven to provide reliable referents for assessing mental model accuracy (Edwards et al., 2006). We averaged the mental models of the referent groups to yield referents for the mental models.

Mental model change was measured in two ways: as *absolute change* and as *updating. Absolute change* was measured as the average of the reverse of the quadratic assignment proportion correlation between team members' mental models before and after the change. In other words, our measure of absolute mental model change reflects the mean dissimilarity between mental models at Time 1 and Time 2. Although absolute change only reflects whether team members did change their mental models from the period before the change to the period after the change, it does not reflect the direction of this change. Therefore, we also derived measures of *mental model updating* that reflect whether team members updated their mental models in alignment with the changes in the task situation. Whereas in the first half of the simulation wind speed and direction were relatively unimportant factors, in the second half they became crucial input factors for teams' strategies. Team members needed to take into account the wind to efficiently prioritize which fires to extinguish first and to decide where they would apply bulldozers to prevent fires from spreading. For example, it would be strategically more efficient to give high priority to a fire that, due to the wind direction, would spread toward a village, rather than to give high priority to a fire that would spread in the direction of a lake.

To derive our measure of mental model updating, we first used UCINET (Borgatti, Everett, & Freeman, 1992) to calculate for each team member the relative centrality of each of the concepts of their mental model. We calculated per team member the average centrality of the wind by averaging their centrality for the concepts of wind speed and direction. Finally, we averaged the centrality scores over the three team members. The resulting measure can be understood as the percentage of the centrality score of the wind relative to the centrality score of the other concepts in the mental models. To assess mental model updating, we will enter into the regression equations the centrality of the wind score after the change while we control for the initial centrality of the wind. By entering the initial centralities before entering the postchange centralities, the postchange values represent the residual or change in centralities from the prechange to the postchange period (Cohen, Cohen, West, & Aiken, 2003).

Team interaction patterns. In line with LePine (2003) we used a measure of role structure adaptation based on recurring patterns of task-related activity. We used indicators of interaction patterns (Stachowski et al., 2009) to capture the structure of the postchange interaction. As an input for pattern recognition we ordered the behavioral data recorded by the NFC simulation in a temporally ordered string of events containing the action that was executed (move, stop, fight, or treat), the vehicle on which the action was executed (helicopter, fire truck, or bulldozer), the person who executed the action (Member 1, Member 2, or Member 3), and the time at which the action was executed. Due to technical problems behavioral data of 7 teams was lost and hence all analyses involving interaction patterns only involve the remaining 39 teams.

We used THEME, a pattern recognition software algorithm (Ballard, Tschan, & Waller, 2008; Magnusson, 2000) to identify patterns in the interaction sequences of the team members. THEME software searches for patterns in temporally ordered event data by first searching for simple co-occurrences of events and then combining these into more complex hierarchically ordered patterns. To be conservative, we set the confidence interval to derive patterns at 0.005, indicating that patterns were only retained if they occurred at a less than 0.5% probability level. To control for the effect of the total number of actions on the number of patterns that could be identified, we set the minimum number of times a pattern should occur to the median frequency of all event types. We derived indicators for the total number of interaction patterns, the number of unique interaction patterns, the average number of switches between team members, the average number of team members in a pattern, the average length of the patterns, and the average hierarchy level of the patterns.

We assessed the dimensionality of the six measures of interaction patterns using principal component analyses on the pattern indicators both before and after the change. From the factor analysis we derived a one-factor solution with an eigenvalue of 4.685, explaining 78.1% of the total variance. Because all variables have high factor loadings (> .789) on the single factor, we aggregated the six measures of interaction patterns into a single underlying dimension of pattern complexity by averaging the *z* scores of the individual measures.

Postchange team performance. Team performance is measured as the percentage of the total area that could have been burnt but that was saved by the team. Consistent with other research, postchange team performance was measured as the team's performance score of the period after the change had taken place controlled for performance before the change (LePine, 2003).

Game experience. We included a control variable for team members' computer/video game experience because researchers have suggested that team member game experience may impact team performance on computer-based simulation tasks (Wilson et al., 2009). We measured game experience with the single questionnaire item "Please indicate how often you played computer games on average during the last year (in hours per week)."

Results

Means, standard deviations, and intercorrelations among all the variables included in the study are included in Table 1. Hypothesis 1 poses that mental model updating after the nonroutine change is positively related to postchange team performance. To test this hypothesis we conducted a hierarchical linear regression with absolute mental model change as well as with mental model updating on teams' adaptive performance scores. To assess the effect of updating, we first entered the centrality of the wind in the prechange period as control variable. Then, in a second step we entered centrality of the wind to assess the effect of the change in this variable on postchange team performance (Cohen et al., 2003). As can be seen from Table 2 (Step 1), absolute mental model change and initial centrality of the wind in the mental model were not related to postchange team performance. However, as can be seen from Table 2 (Step 2), updating of the mental model was significantly and positively related to team performance (β = 4.43, $p < .05$, Cohen's $f^2 = .15$); the more teams increased the centrality of wind characteristics in their understanding of the situation, the better they performed in the postchange period. So, these results provide support for Hypothesis 1.

Hypothesis 2 proposes that initial mental model similarity will be negatively related to mental model updating. Hypothesis 3 proposes that initial mental model accuracy will be positively related to mental model updating.

Table 1. Means, Standard Deviations, and Correlations.

		N	*M*	*SD*	1	2	3	4	5	6	7	8	9
1	Avg game experience	46	2.68	2.86									
2	MM Similarity	46	0.29	0.17	0.02								
3	MM Accuracy	46	0.41	0.12	0.17	0.48**							
4	MM Absolute change	46	–0.49	0.28	0.08	–0.22	–0.23						
5	Wind centrality before change	46	0.12	0.01	–0.13	0.36*	0.14	0.10					
6	Wind centrality after change	46	0.13	0.01	0.00	–0.21	0.12	0.20	0.49**				
7	Patterns before change	39	0.00	0.90	0.01	0.30†	0.04	–0.22	–0.21	–0.35*			
8	Patterns after change	39	0.00	0.88	0.20	–0.06	0.13	–0.05	–0.24	0.05	0.05		
9	Prechange performance	46	82.67	9.72	0.29†	0.09	0.22	–0.14	–0.01	0.06	–0.21	0.28	
10	Postchange performance	46	70.85	12.20	0.19	–0.15	0.27†	0.01	0.16	0.40*	–0.30†	0.40*	0.41**

Note. MM = Mental models.
† $p < .10$. *$p < .05$. **$p < .01$.

Table 2. Regression Results for the Effect of Change in Mental Models and Interaction Patterns on Postchange Performance.

	Postchange performance							
	Step 1		Step 2		Step 3		Step 4	
	β	*M*	β	*M*	β	*M*	β	*M*
Average game experience	0.42	(0.63)	0.37	(0.59)	0.93	(.72)	0.66	(.69)
Prechange performance	0.49†	(0.19)	0.45*	(0.18)	0.33	(.23)	0.27	(.21)
Wind centrality before change	1.56	(1.33)	−0.17	(1.42)	−0.19	(1.84)	0.95	(1.79)
MM absolute change	1.72	(6.24)	−0.94	(5.96)	−2.96	(6.88)	−2.21	(6.46)
Wind centrality after change			4.43*	(1.76)	4.55*	(2.2)	3.13	(2.15)
Total number of actions					0.00	(.02)	−0.02	(.02)
Patterns before change					−1.85	(2.29)	−2.44	(2.16)
Patterns after change							4.98*	(2.19)
Total R^2	0.21		0.32		0.36		0.46	
ΔR^2			0.11		0.01		0.10*	
ΔF			6.35*		0.34		5.14*	
Model *F*	2.69*		3.70*		2.46*		3.09*	

Note. M = 46 for Step 1 and 2, *N* = 39 for Step 3 and 4.
ΔR^2 and ΔF from Step 3 is calculated relative to a Step 2 model including only the 39 cases on which there was complete interaction pattern data.
† $p < .10$. *$p < .05$. **$p < .01$.

To test these hypotheses we conducted hierarchical linear regressions with postchange wind centrality as the dependent variable, controlling for prechange wind centrality. As can be seen from Table 3 neither initial mental model accuracy (Step 2: $\beta = 0.37$, $p > .1$, Cohen's $f^2 = .00$) nor similarity (Step 3: $\beta = -0.62$, $p > .1$, Cohen's $f^2 = .01$) had a significant effect on mental model updating. Thus Hypotheses 2 and 3 were not supported.

Hypothesis 4 predicted that teams' postchange interaction patterns will mediate the relationship between mental model updating and postchange team performance. For this hypothesis to hold, the following conditions should hold: (a) mental model updating should predict team interaction patterns, (b) interaction patterns should predict postchange team performance, (c) mental model updating should predict postchange team performance, and (d) the relationship between mental model updating and postchange team performance should decrease if the variable for postchange interaction patterns is added to the equation (Baron & Kenny, 1986).

To test the relationship between mental model updating and postchange patterns, we regressed pattern interactions on wind centrality after the change, controlling for the total number of actions, interaction patterns before the change, and wind centrality before the change. Table 4 shows that mental

Table 3. Antecedents of Mental Model Updating.

	MM Wind centrality after change					
	Step 1		Step 2		Step 3	
	β	*SD*	β	*SD*	β	*SD*
Average game experience	0.02	(.05)	0.02	(.05)	0.02	(.05)
Wind centrality before change	0.41**	(.11)	0.40**	(.11)	0.37**	(.13)
MM accuracy			0.37	(1.27)	0.88	(1.58)
MM similarity					–0.62	(1.13)
Total R^2	0.25		0.25		0.25	
ΔR^2			0.00		0.01	
ΔF			0.08		0.31	
Model *F*	7.00**		4.59**		3.47*	

Note. $N = 46$.
† $p < .10$. *$p < .05$. **$p < .01$.

model updating marginally predicts pattern complexity (Step 2: $\beta = 0.30$, $p < .1$, Cohen's $f^2 = .09$), providing partial support for the first condition. To test the effects of postchange interaction patterns on postchange team performance, we added the total number of actions, and prechange interaction patterns as control variables. As can be seen from Table 2 (Step 4: $\beta = 4.98$, $p < .1$, Cohen's $f^2 = .11$), postchange interaction patterns significantly predict post-change team performance, thus providing support for the second condition. As we have seen before, mental model updating significantly predicts post-change team performance, providing evidence for the third condition. Finally, as Table 2 (Step 4: $\beta = 3.13$, $p > .1$) shows, the β-coefficient of mental model updating predicting postchange team performance becomes insignificant after interaction pattern complexity is added to the equation. Together, these equations provide support for the mediation effect of Hypothesis 4.

Supplemental Analysis

Although we analyzed team adaptation to a novel situation, it is possible that the teams' success in adapting to the novel task situation was driven not by a team-level realization of the change but instead by a single attentive team member, who might have individually been responsible for the teams' response to the novel situation. If this is the case, adaptation would be a disjunctive task in that it would be the performance of the best performing team

Table 4. Regression Results for the Effects of Mental Model Updating on Pattern Complexity.

	Interaction patterns after change			
	Step 1		Step 2	
	β	*SD*	β	*SD*
Average game experience	0.07	(.05)	0.07	(.05)
Total number of actions	0.00	(.00)	0.00†	(.00)
Patterns before change	0.01	(.16)	0.10	(.17)
Wind centrality before change	–0.13	(.13)	–0.24†	(.14)
Wind centrality after change			0.30†	(.17)
Total R^2	0.16		0.23	
ΔR^2			0.08	
ΔF			3.17†	
Model F	1.53		1.94	

Note. $N = 39$.
† $p < .10$. *$p < .05$. **$p < .01$.

member that would determine postchange team performance (Steiner, 1972). To examine whether the teams' adaptive functioning was driven predominantly by a single team member, we included an additional variable, maximum wind centrality—that denotes the centrality of the wind in the mental model of the team member with the highest wind centrality after the change. If the results reveal an incremental effect of team average mental model updating over the effect of the maximum wind centrality, this provides additional evidence that the effect is driven by a team-level instead of merely an individual-level response.

To test this notion, we conducted a hierarchical linear regression that differed from the regression conducted for Hypothesis 1, only in that we added an extra step in which we entered maximum wind centrality before we added average wind centrality in predicting adaptive performance. The results show that maximum wind centrality after the change was not significantly related to postchange team performance ($\beta = 0.89$, $p > .10$, Cohen's $f^2 = .00$). Moreover, team average mental model updating was significantly related to postchange team performance after controlling for maximum wind centrality ($\beta = 4.54$, $p < .05$, Cohen's $f^2 = .13$). This indicates that it is not sufficient if one member figures out the importance of the wind but instead, the team members should on average realize this.

Discussion

Adaptability is undoubtedly one of the critical attributes of team functioning, particularly when teams operate in complex dynamic situations. For teams to be able to adapt to emerging task situations, they have to develop strong mental models (Cannon-Bowers et al., 1993). Empirical research on the effects of shared mental models on team performance is, to date, limited to a static view on teams leaving questions regarding the dynamic nature of this relationship unanswered. In this study, we draw on multilevel theory of groups (Burke et al., 2006; Marks et al., 2000) and team cognition theory (Cannon-Bowers et al., 1993; Klimoski & Mohammed, 1994) and argue that team mental model updating is an important factor in team adaptability and resides at the crossroads between team inputs and other team processes. In adopting this perspective, we first sought to study team cognitive inputs as antecedents of mental model updating and second, we sought to identify the team processes that account for the effects of mental model updating on postchange team performance.

Team cognitive structures in general and team mental models in particular play an important role as antecedents of team performance (Cannon-Bowers et al., 1993; Marks et al., 2000). As the body of literature on team mental models has accumulated over the last 20 years, empirical investigations of many temporal aspects of team mental models, such as flexibility and change, have been lacking. Although some scholars have hinted at the importance of mental model flexibility for team adaptive performance (Burke et al., 2006; Marks et al., 2000), empirical evidence is still wanting. This study's main contribution is that it is the first, to our knowledge, to empirically demonstrate that mental model updating is positively related to postchange team performance. More specifically, our results indicate that it is not a change in mental models per se, but a specific change in alignment with the change in the task situation that predicts postchange team functioning. These findings confirm earlier theorizing by Weick (1979) and Marks and colleagues (2000) that not only do team mental models change over time but also they have to change and further do it in a specific way for a team to perform successfully and to maintain its competitive edge.

A second purpose of this study was to identify antecedents of mental model updating; specifically, we looked at the effects of mental model accuracy and mental model similarity as potential antecedents. However, we found neither of these variables to be significantly related to mental model updating. This is particularly surprising given that previous studies have consistently shown effects of mental model similarity and accuracy on team functioning under a variety of circumstances (DeChurch & Mesmer-Magnus, 2010). An explanation for why these effects may not have extended to cognitive and behavioral adaptation in the present context may be found in our review of the mental model literature, where there is evidence for opposing mechanisms between both mental model accuracy and similarity and updating. It is possible that the circumstances for the expected mechanisms to become relevant were not present in the setup of the present study or the effects of the positive and negative mechanisms may have equilibrated each other. Below, we will shortly summarize these mechanisms and identify two factors (magnitude of change and stability of mental models) that are likely to impact which mechanism will be most prominent; hence we will demonstrate under what circumstances mental model accuracy and similarity are likely to be positive or negative for updating. Based on this argumentation, we will provide some suggestions for additional research.

We reasoned that there are two opposing mechanisms that may explain the relation between mental model accuracy and updating. Based on existing literature (Burke et al., 2006; Edwards et al., 2006), we argued that initial mental model accuracy provides teams with a fertile starting ground that helps members recognize the need for change and adapt their knowledge structures accordingly. Conversely, following the paradox of success logic it could be argued that high initial accuracy could actually decrease adaptation because it may lead to initial success and consequently to strategic persistence and cognitive rigidity (Audia et al., 2000; Miller, 1993). We argued that given that the teams in the present study only faced a moderate degree of change, the positive effects of mental model accuracy were likely to overshadow the negative effects.

We also reasoned that there are two opposing mechanisms that may explain the relationship between mental model similarity and updating. On one hand, similarity in mental models positively impacts team interaction processes (DeChurch & Mesmer-Magnus, 2010), which should help team members to coordinate their actions in reaction to an environmental change. On the other hand, mental model similarity may negatively relate to the depth of information processing a team engages in when faced with changes in its task situation, and therefore hamper the construction of novel representations of the situation. Whereas previous researchers have mainly emphasized the former mechanism (e.g., Burke et al., 2006; Cannon-Bowers et al., 1993; Marks et al., 2000), we reasoned that given our focus on team members' mental models of their external task situation, the second mechanism would be more prominent in the present context.

The identification of mechanism that may determine whether mental model accuracy and similarity positively or negatively impact updating raises a key question. What factors are likely to moderate the relationship between team mental model characteristics and adaptation? We identify two factors: (a) the magnitude of change in the task context, and (b) the extent to which team members' mental models have been stabilized or entrenched through prolonged experience within a specific domain. Below we will discuss how these factors may impact the effects of mental models on team adaptation.

The magnitude of change refers to the extent to which the elements of the task situation have been altered and the team has to adapt its practices, ranging from incremental change to radical change (Gersick, 1991). We expect that the negative effects of mental model accuracy and mental model similarity will be more prominent, the more drastically the situation changes. When the environment drastically changes, team members need to let go of their previous mental models and fully reconstruct novel task representations (Audia et al., 2000). Under these circumstances, the accuracy of previous mental models is likely to become a liability as people's attachment to models that have been highly functional previously may prevent them from abandoning them (Hodgkinson, 1997). In addition, similarity of mental models may foster additional rigidity as team members may resist letting go of previously established beliefs when these are reinforced by others (Gersick & Hackman, 1990). Moreover, as team members use each other for input when making sense of unexpected occurrences (Roberson, 2006), team members' sensemaking processes are likely to remain closer to the status quo when team members have similar mental models than when mental models diverge. Finally, when team members have diverse mental models, it is more likely that at least one member's mental model is closer to accurate. In the present study we introduced a moderate amount of change, which required teams to abandon some but not all previously acquired routines and practices. Whereas under radical change, mental model accuracy and similarity may lead to rigidity, this is less likely to be the case under more moderate amounts of change. Additional research is needed to examine whether magnitude of change indeed is a moderating factor in the relationship between mental model similarity and accuracy and team adaptation.

The second factor that may qualify the relationship between mental model similarity and accuracy and team updating is the extent to which mental models have become entrenched. Dane (2010) refers to cognitive entrenchment as the stability in cognitive schema that arises from prolonged experience in a certain domain and the consecutive development of complex knowledge structures that become resistant to modification. Entrenchment is related not only to reliability and speed of task execution but also to cognitive rigidity and the inability to identify creative solutions for novel situations (e.g., Hodgkinson, 1997).

Cognitive entrenchment is likely to impact the effect of mental model accuracy and similarity on adaptation in different ways. On one hand, the positive effect of mental model accuracy in terms of reducing cognitive load is likely to become stronger when these models have consistently and repeatedly been applied in practice. When team members have repeatedly enacted their mental models, this model-based action execution will become more highly automated and less resource intensive than when the models are recently constructed (Ericsson & Kintsch, 1995; Rouse & Morris, 1986). This effect may be even more pronounced when team members have similar mental models as the consistent application of similar and accurate mental models is likely to lead to highly efficient routinized team interactions (Kanki et al., 1991; Stachowski et al., 2010). However, these same effects are also likely to foster rigidity, as team members may become reluctant to let go of highly efficient mutually reinforced mental models even when these have become suboptimal in novel task situations (Audia et al., 2000; Dane, 2010). Moreover, when mental models have become highly entrenched they become more determinant in guiding team members' perception of situational cues, which may decrease the chance that anomalies are detected and interpreted as signaling a need for change (Walsh, 1995).

Given the relatively short period over which team members developed knowledge on executing the firefighting simulation in the present study, the cognitive entrenchment of the mental models they developed for this task is likely to be low. Therefore, future research may investigate the effects of mental model stabilization on team adaptation by varying the period over which mental models have been used before a change is introduced.

Finally, we sought to identify a mediating process that would account for the effect of mental model updating on postchange team performance. Through their interactions, teams acquire experiences, information, and knowledge, which come together to influence team performance (Gersick & Hackman, 1990). We found a strong and significant relationship between postchange team interaction patterns and postchange team performance. Moreover, team interaction patterns mediated the relationship between mental model updating and postchange team performance. Substantively, our results indicate that the longer and more complex the patterns that teams applied in the postchange period, the better their adaptive response. Furthermore, teams that incorporated the change in their mental models reacted to this change by developing and applying interaction patterns that fit the novel task situation. At first sight, this finding seems to be in contradiction with previous research on the benefit of interaction patterns under nonroutine circumstances. Stachowski and colleagues (2009) found that, during a crisis situation, higher performing nuclear power plant crews exhibited fewer, shorter, and less complex interaction patterns than less effective crews. However, their study focused on interaction patterns derived from communication; in the present study, interaction patterns were measured from the micro-behavioral data recorded in the simulation. Hence this difference in findings may be explained by the level at which routines were assessed in the two studies. Complexity in communication patterns may indicate a lack of automatic processing of information on a more tactical or strategic level—for example, if communication is extremely standardized, it is likely that team members are sticking closely to well-trained protocols. Complexity in behavioral interaction patterns, on the other hand, occurs at a much lower level—the duration of a single interaction pattern is at most a few seconds long and represents only a fraction of the team performance episode. In many adaptive situations, it is likely that whereas higher level routines have to be adapted to fit the novel situation, many lower level routines will remain functional under the new circumstances.

Moreover, a team's ability to rapidly develop novel routines for new task situations may be an important component of team adaptability (LePine, 2005). Indeed, recent work suggests that the chaotic flux, or "unstable, unbalanced, or changing pattern of interaction," experienced by a team after encountering a disruptive event exerts a negative influence on team performance (Summers et al., 2012, p. 315). This work suggests that the ability of teams to minimize flux and quickly create new patterns of interaction after experiencing a disruptive event would play an important role in team adaption and performance. Future research should address these effects in more detail and more precisely pinpoint what types of routines are beneficial and what types are detrimental to team performance under nonroutine circumstances.

Limitations

The findings of this study should be interpreted with an appropriate amount of caution. Because we measured mental models only at two points in time, this did not allow us to trace and pinpoint exactly when cognitive restructuring of team members' mental models took place. We chose to implement our postchange mental model measure at 5 min after the change, following previous work that indicates that the speed of team adaptation is crucial for team adaptive performance (Waller, 1999) and our analysis of the simulation, which indicated that to maintain high performance levels, teams should update their understanding of the situation within 5 min after the change.

However, given that we only had one postchange measurement of mental models, we could not measure the actual speed of adaptation.

Another limitation of the study is that by using averages for team mental models, our treatment of cognitive change is relatively simplistic. Our methods do not address whether the recognition of cues signaling the need for change and subsequent updating of mental models is initiated by single team members or whether members conjointly engage in these processes. Future research could extend these findings by tracing more accurately which team members signal a need for change and how cognitive changes are communicated and dispersed within teams.

In addition, our measure for mental model updating assumes that when faced with a change in the task structure, team members adapt their knowledge structures to more closely resemble the underlying task situation. Research from the field of learning, however, indicates that when confronted with novel situations, instead of abandoning previously established associations between variables, individuals are more likely to add information in terms of qualifiers to their existing associations (e.g., Bouton, 2002). If we translate this mechanism to the context of mental models, qualifiers would indicate under what circumstances a particular mental model would be appropriate for a situation. Because the mental model measures we used in this study are situation specific—team members were asked to indicate how they understood their present situation—we could not draw any conclusions about whether team members simply adapted the parameters in their mental models or if they included situation qualifiers that indicated under what specific situations those parameters would hold. The goal for our research, however, was not to realistically depict the cognitive structure of team members' mental models but to investigate whether adaptive change in team members' mental models plays a role in team adaptation. Research with more elaborate mental model measures is required to more accurately capture how such adaptive changes are incorporated in team members' knowledge structures.

Conclusion

An abundant amount of previous studies has shown the importance of characteristics of mental models, such as similarity and accuracy, for predicting team performance (DeChurch & Mesmer-Magnus, 2010). However, although anecdotic evidence stresses the importance of flexible adaptation of knowledge structures in the light of novel circumstances (e.g., Marks et al., 2000), extant work has often treated characteristics of mental models as static variables. By investigating the effects of mental model updating on the development of novel interaction patterns and team performance, we bridge this gap and tie into a growing body of research that considers the temporal notion of cognitive updating as central to understanding individual and team adaptation (Rudolph, Morrison, & Carroll, 2009). Team cognition, after all, is no fixed construct but a dynamic process that occurs over time as teams act in and make sense of their changing environments.

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